Evaluation of Intelligent Routes for Personalised Electronic Tourist Guides

Ander Garcia[a], Maria Teresa Linaza[a], Olatz Arbelaitz[b]

[a] Dept. of eTourism and Cultural Heritage
Vicomtech, Spain
{agarcia, mtlinaza}@vicomtech.org

[b] Dept. of Computer Architecture and Technology
University of the Basque Country, Spain
olatz.arbelaitz@ehu.es

Abstract

Personalised Electronic Tourist Guides (PETs) provide an integrated solution for route generation based on the profile and constraints of the tourists, and up-to-date Points Of Interest (POIs) and destination information. In this paper we present the result of an evaluation of a PET prototype that applies an advanced algorithm to generate personalised tourists routes including public transportation. The prototype has three main functionalities: recommendation, personalised route generation and route customisation. The validation scenario of the prototype has been the city of San Sebastian. The result of the validation has been positive and it showed that PETs are perceived as interesting tools by tourists. Moreover, both the personalised route generation and the inclusion of public transportation are perceived as valuable functionalities.

Keywords: Personalised Electronic Tourist Guide, public transportation, evaluation

1 Introduction

The main objective of Personalised Electronic Tourist Guides (PETs) (Garcia *et al.*, 2009) is to provide an integrated solution for personalised route generation based on the profile and constraints of the tourists, and up-to-date information about Points Of Interest (POIs) and destination. Currently, this is a time consuming task that is often done by the Local Tourist Office (LTO) staff. However, routes generated by the staff do not take into account circumstances that may occur during the visit (longer time spent visiting an attraction, changes in the weather, transportation delays, etc.) (Dunlop, Ptasinski and Morrison, 2004). Moreover, due to physical (office location, available space, etc.) and temporal constraints (timetables, travel times, etc.), it is not possible for all tourists to visit a LTO.

PETs help tourists in these tasks, offering added-value functionalities (Vansteenwegen and Oudheusden, 2007). The personalised tourist route generation process of PETs can be described by three basic steps (Fig. 1) (Garcia *et al*., 2010).

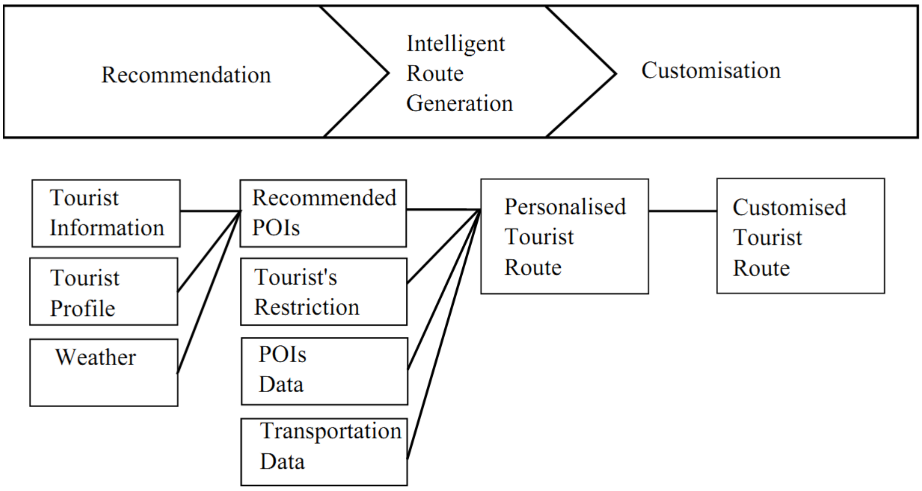

Fig. 1. Steps of the personalised tourist route generation process (Garcia *et al.*, 2010)

- **Recommendation**. A list of recommended POIs can be generated combining information about the destination and tourist profiles. Thus, each POI should have a different score and visit duration for different tourist profiles. For each tourist, these values are stored in their Personal Interest Profile. Interested readers can find a comprehensive review of tourist recommendation systems in a recent paper (Kabassi, 2010).

- **Intelligent Route Generation**. Once the system has determined which the most appealing POIs for the tourist are, an intelligent routing engine applies an algorithm combining this information with the restrictions of the tourist (available time, duration of the route, budget, start POI); POI data (location, opening hours, ticket price); destination context data (weather, special events); and transportation data (travel times, public transportation network data) to generate personalised tourist routes.

- **Customisation**. Finally, tourists can customise the proposed personalised route to better fit their needs. Inserting new visits and removing or reordering visits on the route are the basic functionalities of a customisation engine.

This paper summarises the validation of a PET prototype that has been developed to evaluate route generation functionalities. The prototype applies an advanced algorithm to generate personalised routes including public transportation. The objective of the validation is to analyse if tourists perceive these functionalities offer an added value, encouraging their inclusion in next generation travel guides.

The paper is organised as follows. First, we present a summary of related work. The next Section introduces the prototype of the validation. Finally, we present the results of the validation. The last Section remarks the main conclusions and some future work lines.

2 Related work

2.1 Route generation functionalities of PETs

During the previous decade, advances both in hardware and mobile networks have fostered the development of new PET prototypes, which have received different names such as Mobile Tourist Guides, Personal Navigation Systems for Tourism, Electronic Tourist Guides or even Tourist Decision Support Systems. Existing PETs have been thoroughly reviewed in the literature (Souffriau *et al.*, 2008; Kenteris, Gavalas and Economou, 2010; Garcia, 2011).

Although requirements and the main functionalities of PETs were detected while evaluating initial prototypes, not all of the functionalities have received the same attention. Specifically, there are mature examples of recommendation functionalities available (Kabassi, 2010), while the route generation functionality has been relegated to a secondary category, not applying advanced algorithms from other fields.

The generic personalised tourist route generation problem has been defined as the Tourist Trip Design Problem (TTDP) (Vansteenwegen and Oudheusden, 2007). The TTDP presents a general model that serves as a reference for the implementation of PETs. The TTDP describes the characteristics that a perfect PET should meet regarding route generation, integrating the selection and planning of visits to POIs. Thus, its solution selects the best combination of interesting POIs for a tourist and schedules a feasible route.

As the TTDP presents several properties of an ideal PET, it is difficult for real PETs to implement all of these properties. Thus, researchers have proposed different problems to model the route generation problem as simplified versions of the TTDP. One of the simplest problems that can be used as a basic model of the TTDP is the Orienteering Problem (OP) (Tsiligirides, 1984). The OP is based on the orienteering game, in which several locations with an associated score have to be visited in order to obtain a total route score. Each player can visit each location only once.

Extensions of the OP have been successfully applied to model the TTDP. One of the most advanced extensions is the Team Orienteering Problem with Time Windows (TOPTW) (Savelsbergh, 1985), which includes multiple routes and time windows that can be applied to model opening hours of the POIs and multiple day routes. The prototype of this paper introduces a solution to the Time Dependent Multi Constrained Team Orienteering Problem with Time Windows (TDMCTOPTW) (Garcia *et al.*, 2011), an extension of the OP that can be applied to model opening hours of the POIs, multiple day routes, multiple tourist constraints (for example a maximum budget), and public transportation.

Focusing on existing PETs, the oldest examples of prototypes generating routes have proposed approaches based on models of the TTDP and algorithms that are either too simple or not efficient. Two approaches, P-Tour (Maruyama et al., 2004) and DTG

(Hagen et al., 2005) propose advanced models but fail to implement an efficient solution. However, the most recent example, City Trip Planner (Vansteenwegen *et al.*, 2010), models the TTDP as the TOPTW and proposes and efficient solution algorithm to solve it in real-time. Finally, m-Trip is a commercial PET (www.mtrip.com., [July 10, 2011]) that applies a custom engine, called Genius, to generate personalised tourist routes for the main cities of the world.

The PET evaluated in this paper (Garcia *et al.*, 2009; Garcia *et al.*, 2010) applies a solution algorithm for the TDMCTOPTW that generates routes in real-time. This is the first example of both a solution algorithm for the TDMCTOPTW, and a PET generating personalised route in real-time and including public transportation, which was identified as one of the most valuable functionalities of PETs (Schmidt-Belz *et al.*, 2003; Stroobants, 2006; Beer *et al.*, 2007).

Although there are algorithms (Delling *et al.*, 2009; Bauer *et al.*, 2010) to generate routes between two locations (for example a route from the hotel to the cathedral) and including public transportation, the problem they solve is different. This problem, known as The Time Dependent Shortest Path Problem (TDSPP) (Cooke and Halsey, 1966) or the Earliest Arrival Problem (Pyrga *et al.*, 2008) is a time-dependent problem for individual queries between locations. Thus, this problem does not model the selection of the locations that should be included in the route and its solution algorithms are not suitable for the generation of personalised tourist routes.

2.2 Evaluation of existing PETs

Researchers have conducted evaluations of some existing PETs focusing on their tourist features and applying methodologies based on direct observation of tourists, semi-structured interviews, questionnaires and on-line surveys. For example, Chevers *et al.* (2000) presented their experiences developing and evaluating the GUIDE prototype, concluding that tourists appreciated the benefits of their PET. Some years later, Schmidt-Belz *et al.* (2003) remarked the importance of offering new services (such as services related to transportation) as a conclusion of their evaluation of the CRUMPET prototype. More recently, Kramer *et al.* (2007) focused on the behaviour of tourists following routes generated by the DTG prototype, suggesting PETs could help tourists enjoy the full potential of destinations. Finally, Rasinger, Fuchs, and Höpken (2007) presented a survey on usage intention of different tourist mobile information services in tourism, identifying transportation information as one of the top-six services.

However, the recent mobile revolution (smart-phones, mobile Internet ...) has opened new development possibilities for PETs that were not available some years ago. For example, none of the existing PET prototypes could generate personalised tourist routes including public transportation, which is one of the functionalities tourists find more valuable.

Thus, after having successfully developed a PET prototype that could generate personalised tourist routes including public transportation in real-time, we have validated it in a real scenario. The evaluation presented in this paper analyses the importance of personalised route generation and public transportation functionalities for PETs, fostering further research and developments that take advantage of the new technical possibilities available nowadays.

3 Description of the prototype

3.1 Main functionalities of the prototype

Although PETs can include several functionalities, in order not to deviate from the main objective of the validation, we have focused on the route generation functionalities. Thus, we have avoided the development of a complete PET, which would have required a considerable development effort in areas already covered by prior research. The prototype (Garcia *et al.*, 2009; Garcia *et al.*, 2010) is a Web application that includes the following functionalities (Fig. 2):

- Generation of personalised tourist routes. The prototype allows tourists to generate personalised tourist routes that maximise their enjoyment when visiting a city. First, tourists have to enter some data about their preferences (Fig. 2-1) and the constraints of their route (Fig. 2-2).

  As it has been remarked in previous sections, recommendation is not the main functionality of the prototype. The recommendation functionality of the prototype is based on a matrix that relates tourist profiles defined by the LTO and POIs. Tourists using the system have to define their profile, introducing to what degree they feel identified with the defined profiles. More advanced recommendation techniques are summarised by Kabassi (2010) and are not within the scope of this paper.

  Then, a personalised route is generated and showed on a map with the details of each visit (Fig. 2-3a). Tourists are allowed to customise the proposed route to better meet their requirements (Fig. 2-3b). Finally, tourists can generate a detailed summary and a PDF of the route (Fig. 2-4).

- Inclusion of public transportation. The generated routes should encourage the use of public transportation, when convenient. The summary of the route shows how to move between visits, including the details about the public transportation stops and services.

- Customisation of the generated routes. Tourists can refine the proposed route (Fig. 2-3b) applying six basic operations: add a visit; remove a visit; move a visit towards the beginning of the route; move a visit towards the end of the route; move a visit to the previous day; and move a visit to the next day.

- Real-time execution. The prototype runs in real-time, generating and visualizing the personalised route in less than five seconds to provide an interactive experience.

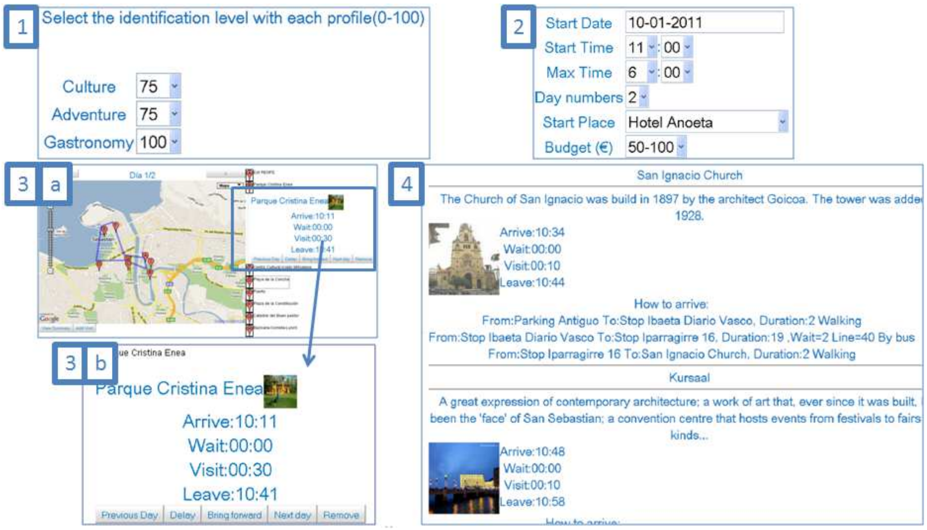

Fig. 2. Functionalities of the prototype

3.2 Implemented algorithm

The prototype applies an advanced algorithm to generate personalised tourist routes in real-time including public transportation (Garcia *et al.*, 2011). We have modelled the TTDP as the Time Dependent Multi Constrained Team Orienteering Problem with Time Windows (TDMCTOPTW). A typical TDMCTOPTW contains a number of POIs with a fixed location, opening hours (time windows), and a given score; and several constraints. Movements between POIs can be done on foot or by public transportation. The public transportation network is defined by a number of fixed stops and different lines between these stops, each of them with a given frequency.

The algorithm applies a real calculation approach modelling public transportation transfers as direct connections. The approach is based on a fast evaluation of the possible insertion of an extra POI to a route, evaluating each insertion locally and efficiently. Our algorithm is the first solving this type of problems in real-time. Interested readers can access a thorough description of the algorithm (Garcia *et al.*, 2011).

We have already validated the efficiency of the algorithm using test instances based on real data about the city of San Sebastian and it is able to generate routes in less than one second for 50 POIs and two day routes. In this paper we focus on the validation of the PET prototype integrating this algorithm from the tourist point of view.

4 Validation

4.1 Objectives of the validation

The objectives of the validation of the prototype are twofold. On the one hand, we want to check the real world viability of the approach to generate personalised tourist routes within the tourism domain. On the other hand, we have used the validation to discover more aspects on the opinion of tourists relating to route generation functionalities and PETs: what they expect and what they would like a perfect PET to include.

4.2 Methodology of the validation

We used a quantitative analysis approach for the validation. Data was collected on the basis of a questionnaire developed for the usability analysis, including aspects related to different constructors such as the perceived usefulness (PU) of the prototype, its perceived ease of use (PEOU) or the perceived added-value.

The first part of the questionnaire focused on the profile of the user and was composed of demographic data (age, gender, nationality, country of residence), general information (first time visitor, languages spoken, prior technological and mobile knowledge), and tourist preferences (information sources, tourist interests, transportation means). The second part focused on parameters of the Technology Acceptance Model (TAM) and the assessment of the prototype, the ease of use of the functionalities and the perceived value of the prototype. The last part focused on the assessment of PETs, asking tourists about the services they would expect from an ideal PET and their willingness to pay for them.

The validation process started by giving tourists a short explanation of the prototype. Then, we asked them to generate a route for themselves and to customise it until they were satisfied with the route. Finally, we asked them to complete the questionnaire. The whole process took around 30 minutes for each tourist. The answers were processed and analysed to form a judgement on the technical performance of the system, usability aspects of the prototype and overall aspects related to PETs.

4.3 Validation scenario

The prototype has been validated in the city of San Sebastian, which is a medium size city of approximately 200,000 inhabitants and 50 POIs distributed throughout the city. Although most of the POIs are located around the three beaches of the city and the city centre, it is not desirable to visit all POIs on foot. Therefore, most of the tourists visit the city combining public transportation with short walks.

4.4 Sample data

Twenty tourists and professionals from the tourism sector (researchers and Information Technology company employees) took part in the validation (11 men and

9 women) in November 2010. 15 of them were between 20 and 39 years old; three between 40 and 59; and two of them between 10 and 19. 18 of them were Spanish (half of them from outside the region of Gipuzkoa); one was Irish; and another was French. Regarding their previous knowledge about the city, most of them lived in, or near, San Sebastian (11 of them); six were frequent visitors to the city; and three of them had prior knowledge of the city.

Regarding their technological background, most of them were familiar with new technologies. All of them often used PCs, the Internet and a mobile phone; and had at least infrequently used digital cameras (both stand alone and mobile phone cameras). GPS units were not so familiar, as five tourists had never used them. Video cameras were also not used often; ten tourists had never used a stand-alone video camera and four, a mobile phone video camera. Tourist applications were quite unknown. 14 tourists had never used any type of PET and 12 of them had never used a traditional audio guide. These results confirm that tourist applications are not widespread among users, not even in a sample with an average technological knowledge as the one taking part in the validation.

The most popular tourist information sources (used by nearly all tourists) were Internet (20); Web pages of the Destination Management Offices (DMOs) (20); friends (19); and Local Tourist Offices (LTOs) (19). Printed tourist guides were used by nearly 15 people. On the contrary, around half of the tourists never used hotels (8); hotel Web sites (9); social networks (8); specialised forums (7); or travel agencies (9); as sources of tourist information.

Participants used different transportation means to arrive to San Sebastian. Nine of them came by car; four by train; four by bus; and three by other means of transportation. Regarding the use of public transportation while visiting the city, only one tourist did not want to use it. This highlights the importance of providing information about public transportation, which has also been identified by previous studies (Schmidt-Belz *et al.*, 2003; Stroobants, 2006; Beer *et al.*, 2007).

4.5 Results of the validation

Focusing on the prototype, most tourists (around 80% for most offered functionalities) found it easy to perform different tasks (Fig. 3). Customising the profile, which consisted of updating the score and visit time for each POI, was not considered easy by three tourists; and customising the generated route by two. Only one person found difficulties with the generation of a profile, the generation of a personalised route and the navigation through the map.

Nearly all tourists found the prototype easy to use (19) and considered it was clear what the system expected from them at each step of the interaction (14) (Fig. 3). The time required to create a profile (17) and to generate a route (15) was considered acceptable. Most tourists considered the proposed route sufficiently satisfying (14) and the proposed POIs met their interests (16). This general feedback about the prototype was very good and encourages further research and development.

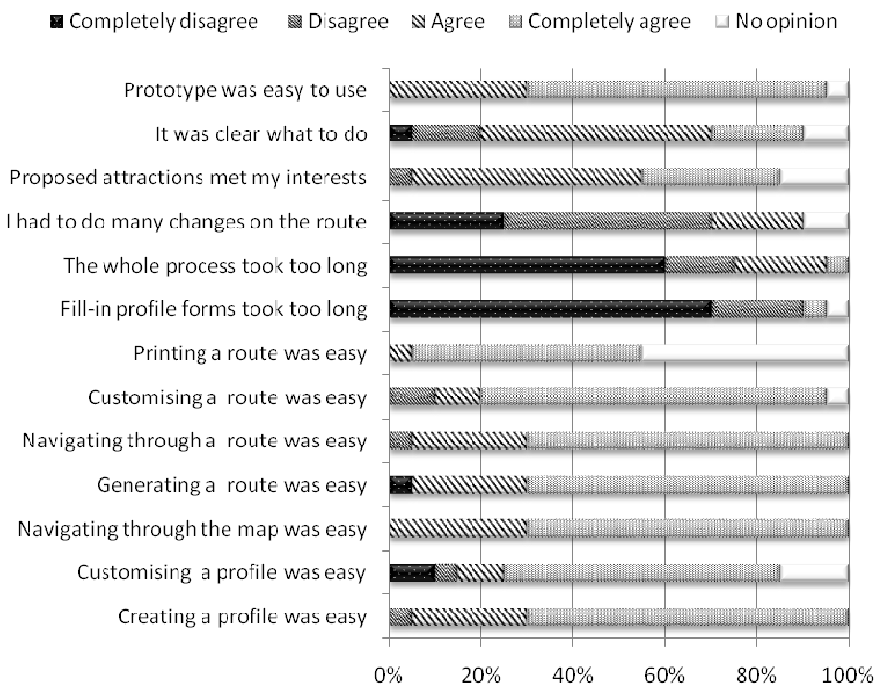

Fig. 3. Opinion about the prototype of the participants of the validation

Participants were quite satisfied with the prototype. Most of them would recommend it (17), and would use it again in San Sebastian (15) or in another city (18). 15 of them would like to use the prototype on their mobile phone. Most of them (18) also considered the prototype was suitable to discover a city and its Cultural Heritage more effectively. Moreover, more than 75% of them (16) perceived a city offering a similar experience as a more technologically advanced city. These results are very positive, as they confirm the perceived utility of the personalised route generation with public transportation is high amongst tourists.

The relationship between the perceived value of the prototype and the amount of money tourists would pay to use it has been diverse. Nearly half of the sample would pay nothing (7) or less than one euro (2) for the prototype. The remaining tourists would pay between one and three euro (5); between three and five (3); and between five and ten (3). No one would pay more than ten euro. These quantities are in the range of values of the tourist applications available on the market, with both free applications and some applications that usually do not cost more than ten euro.

Participants were asked about their ideal PET (Fig. 4). All tourists considered lists of POIs, public transportation information, and maps as important functionalities. Some tourists were reluctant about some of the functionalities: promotions and coupons (7); practical information (7); shopping guides (4); restaurant guides (1); and door-to-door navigation (1). Again, participants considered both personalised route generation and public transportation important aspects of an ideal PET.

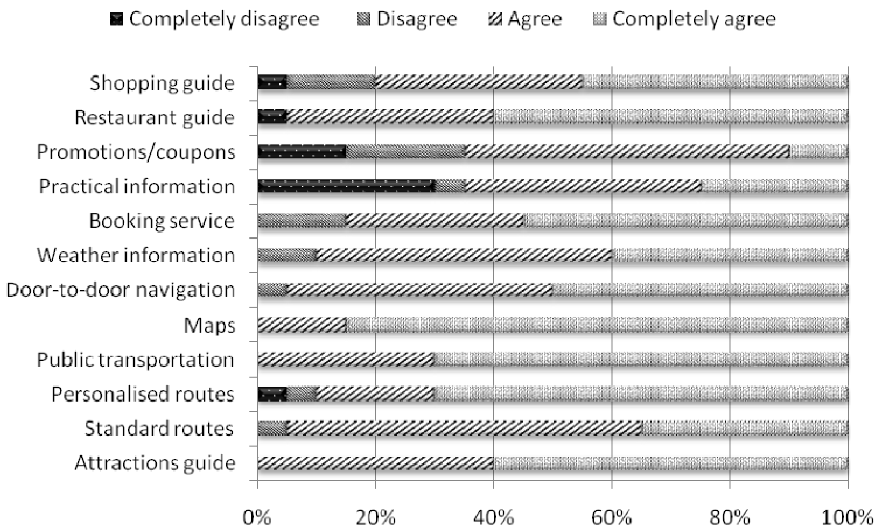

Fig. 4. Opinion about the functionalities of an ideal PET of the participants of the validation

The monetisation of the ideal PET presents differences from the prototype. Nearly half of tourists would pay nothing (6) or less than a euro (3) for it. The remaining tourists would pay between one and three euro (3); between three and five (2); and between five and ten (5). One tourist would pay more than ten euro for an ideal PET. Participants would pay more for the ideal PET, which includes all the functionalities they consider important, than for the prototype, which includes only a subset of these functionalities.

The validation showed that PETs are perceived as interesting tools by tourists. Moreover, both the personalised route generation and the inclusion of public transportation are perceived as valuable functionalities. This encourages the implementation of these functionalities in a real and fully functional PET.

5 Conclusions

This paper presented the validation of a PET prototype focused on the route generation functionality including public transportation. The validation scenario has been the city of San Sebastian, with 200,000 inhabitants; around 50 POIs distributed through the city; and a dense public transportation network.

Although the prototype has three main functionalities (recommendation, personalised route generation and route customisation), the main focus of the prototype and the validation is the route generation functionality. The personalised route generation applies an advanced algorithm to solve problem instances in real-time and including the public transportation of the city. Once tourists obtain a personalised route, they can customise it to better fit their requirements.

The result of the validation with twenty participants has been positive and encourages the inclusion of the personalised route generation functionality in PETs. Most tourists would recommend the prototype (85%) and would use it again on their next visit to San Sebastian (75%). Nearly all of them would like to use it in another city (90%). Tourists found the prototype easy to use and think PETs have many interesting functionalities to offer, including public transportation and personalised routes.

The difficulties of monetising PETs was reflected by the fact that half of the tourists would pay nothing, or less than a euro, even for a perfect PET. However, a third of the tourists would pay more than five euro for it. This situation is reflected by the market, where some PETs are offered for free (including advertisement for example) and some PETs have to be paid for (for example, existing PETs for iPad such as the DK Eyewitness Paris Travel Guide (itunes.apple.com/us/app/paris-dk-eyewitness/id403266639 [July 10,2011])).

As future work, we propose to integrate the personalised route generation functionality, including public transportation, in a fully functional PET in order to validate it in different cities.

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